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DRAFT

BIOVENTING TEST WORK PLAN AND INTERIM TEST RESULTS REPORT FOR UNDERGROUND STORAGE TANKS LOCATED AT BUILDING 7705 WESTOVER AIR FORCE BASE, MASSACHUSETTS

ES ENGINEERING-SCIENCE

Prepared For

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

439th Civil Engineering Squadron
Westover AFB, Massachusetts

Prepared By

ENGINEERING-SCIENCE, INC.

290 Elwood Davis Road
Liverpool, New York 13088

December 1993

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PART I

DRAFT BIOVENTING TEST WORK PLAN FOR UNDERGROUND STORAGE TANKS AT BUILDING 7705 WESTOVER AFB, MASSACHUSETTS

Prepared for

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AFB, TEXAS

and

439TH CIVIL ENGINEERING SQUADRON
WESTOVER AFB, MASSACHUSETTS

by

Engineering-Science, Inc
290 Elwood Davis Road
Liverpool, New York

September 1993

DAB/WESTOVER/WP2

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PART I

DRAFT BIOVENTING TEST WORK PLAN FOR UNDERGROUND STORAGE TANKS AT BUILDING 7705 WESTOVER AFB, MASSACHUSETTS

SECTION 1.0 INTRODUCTION

This test work plan presents the scope of an *in situ* bioventing pilot test for treatment of fuel contaminated soils associated with the underground storage tanks (USTs) at Building 7705 (Pump House) at Westover AFB, Massachusetts. The pilot test has three primary objectives: 1) to assess the potential for supplying oxygen throughout the contaminated soil depth, 2) to determine the rate at which indigenous microorganisms will degrade fuel when stimulated by oxygen rich soil gas, 3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated below regulatory standards.

Pilot testing will consist of two phases, an initial air permeability and *in situ* respiration test which will take place in October of 1993, and an extended one-year pilot test which will be used to determine the potential for bioventing remediation using natural nutrient levels. Extended testing will also provide an estimate of cold weather biodegradation rates. The initial and extended pilot test will serve as treatability studies under the CERCLA feasibility study process. If bioventing proves to be feasible at this site, pilot test data may be used to design a full scale remediation system and to estimate the time required for site cleanup.

The initial test will involve injection at a vent well with a regenerative blower to produce a radius of influence of at least 40 feet. *In situ* rates of fuel biodegradation and soil gas permeability will be determined during this short term test and a decision on how best to proceed with extended testing will be made.

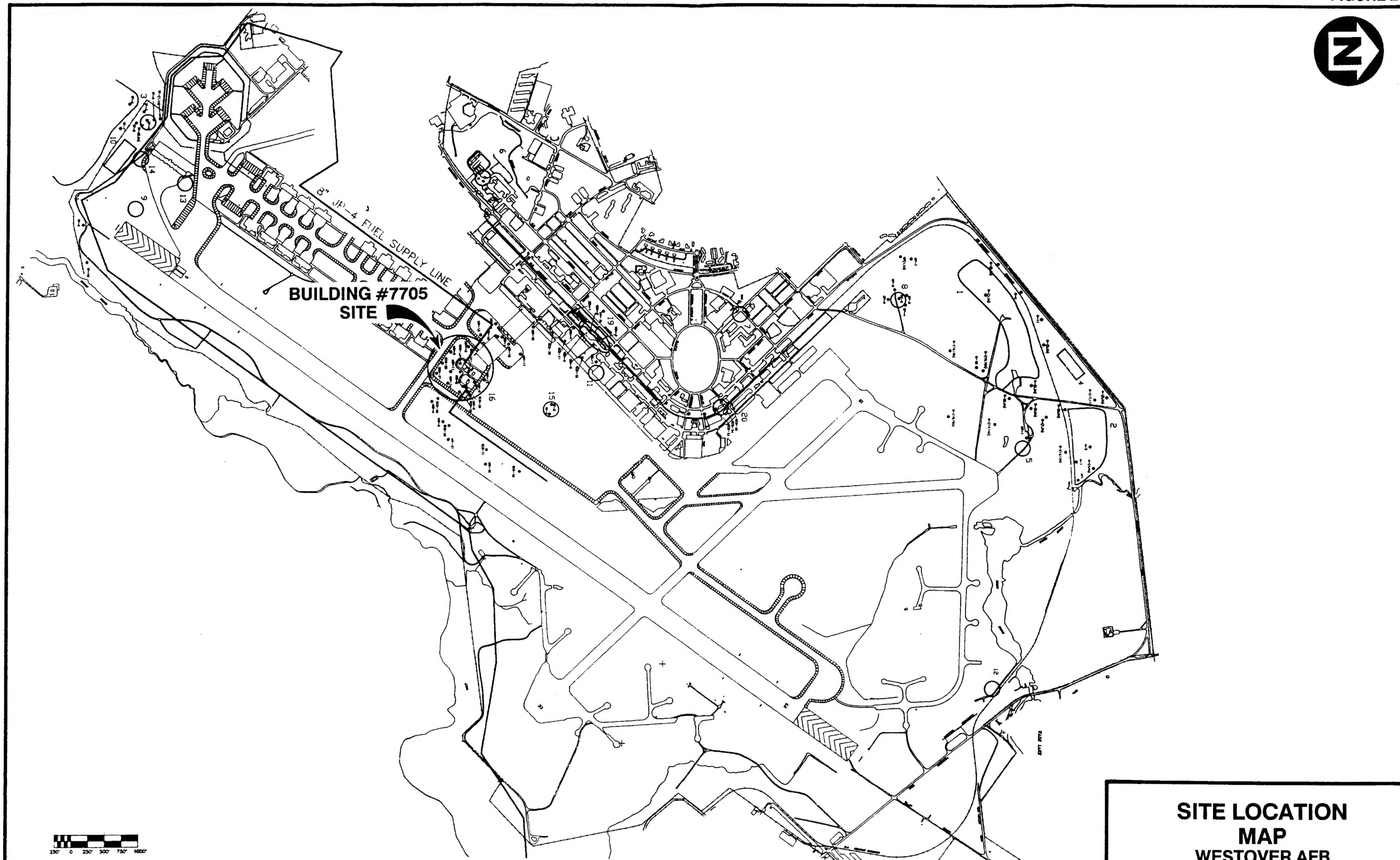
Additional background information on the development and recent success of the bioventing technology is found in the document entitled *Test Plan and Technical Protocol For A Field Treatability Test For Bioventing* (Hinchee et al., 1992). This protocol document is a supplement to the site-specific work plan, and it will also serve as the primary reference for pilot test vent well designs and detailed test objectives and procedures. Unless otherwise noted, test procedures outlined in the protocol document will be used during the pilot tests at Westover AFB.

SECTION 2.0 SITE DESCRIPTION

2.1 Location and History

Building 7705 is located in the central portion of the base in the JP-4 pumping facility area at the northeast end of the fuel supply line (Figure 2.1). There are currently eight 25,000 gallon underground storage tanks (USTs) in operation through Building 7705. All of the tanks, which are estimated to be 50 years old, have been cleaned and upgraded with a lining. Site investigation activities in the

FIGURE 2.1



SITE LOCATION MAP
WESTOVER AFB
CHICOPEE, MASSACHUSETTS

DE 268.37.02

ENGINEERING - SCIENCE

area have indicated soils and groundwater are contaminated with JP-4 jet fuel. The sources of contamination are suspected UST leaks, historic activities in the fuel hydrant area, and a JP-4 fuel spill during Desert Shield activities. The hydrocarbon soil contamination at this site is the target for bioventing treatment at this site.

2.2 Site Geology

Because the bioventing technology is applied to the unsaturated soils, this section will primarily address soils above the shallow aquifer. Soils above the water table at this site consist of fine to medium sand to 15 feet and fine sand with trace silt to at least 20 feet. Groundwater is encountered within this sand at a depth of approximately 10 to 18 feet and generally flows in a south-southeast direction. Soil conditions are typically moderate to high permeability with a high water table.

Due to the homogeneous nature of the sandy soils at Westover AFB, the permeability of soils to air flow should remain relatively constant across the site. Effective bioventing on this site is likely. Battelle has completed a successful bioventing project at Westover AFB, and we are confident that oxygen can be distributed in these soils.

2.3 Site Contaminants

The primary contaminants at the Building 7705 site source area are JP-4 residuals which have migrated to a depth of approximately 18 feet, the maximum depth to groundwater in the area. Total petroleum hydrocarbon (TPH) concentrations above 2,000 mg/kg have been detected in the soils above the shallow aquifer (Battelle, 1993). No free phase product has been observed in any of the groundwater monitoring wells installed at the site.

SECTION 3.0 PILOT TEST ACTIVITIES

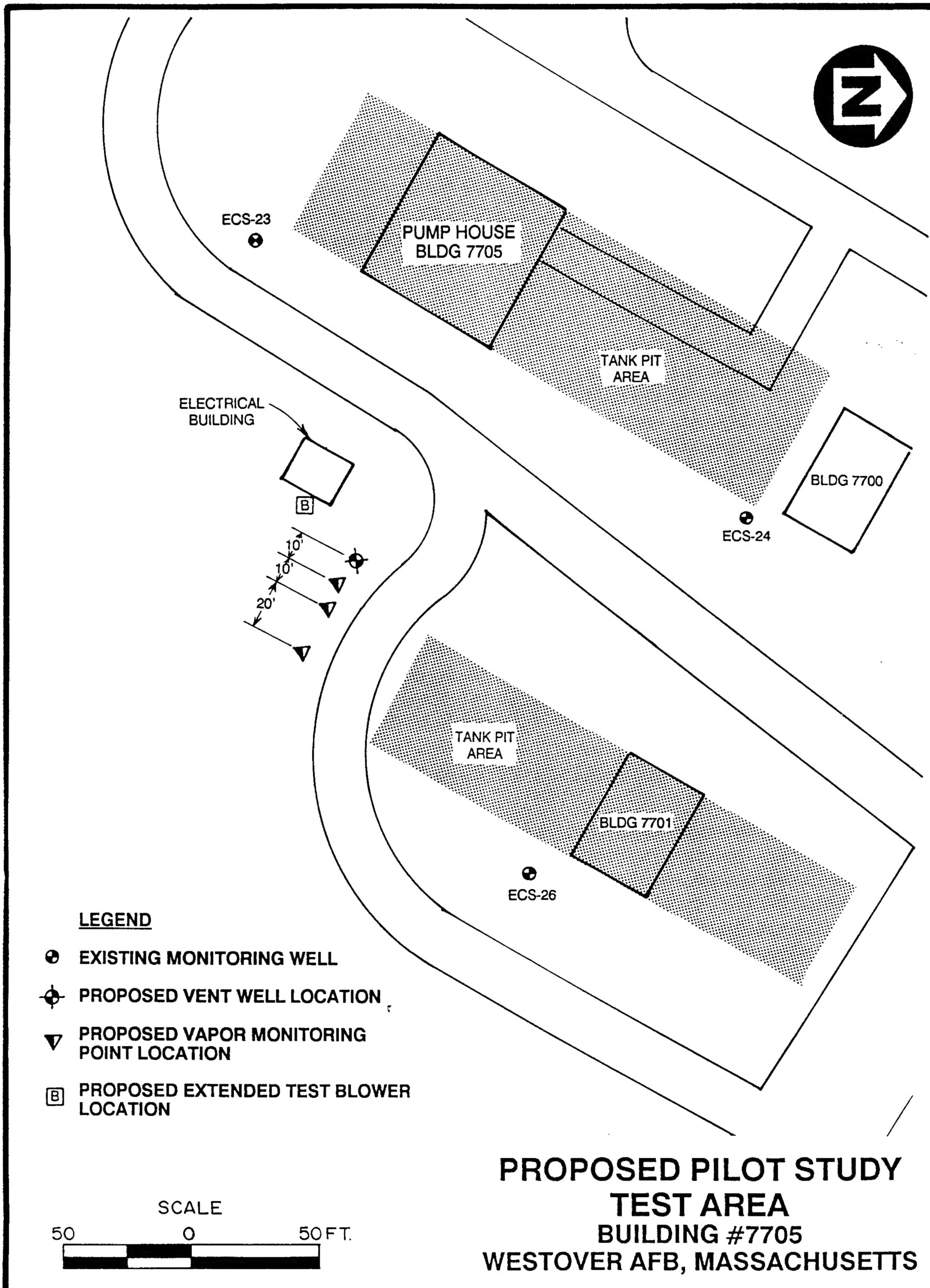
3.1 Introduction

The purpose of this section is to describe the work that will be performed by Engineering-Science, Inc. (ES) at the Building 7705 site. Activities that will be performed at the site include siting and construction of a central vent well (VW) and three vapor monitoring points (VMPs); an *in-situ* respiration test; an air permeability test; and the installation of an extended bioventing pilot test system. Soil and soil gas sampling procedures and blower configuration that will be used to inject air (oxygen) into contaminated soils are also discussed in this section. In an effort to be as cost effective as possible, a single VW will be completed to the depth of lowest seasonal groundwater at the site. Pilot test activities will be confined to unsaturated soils remediation; no dewatering will take place during the pilot test. Existing groundwater monitoring wells will not be used as primary air injection or extraction wells. However, monitoring wells which have a portion of their screened interval above the water table may be used as VMPs or to measure the composition of background soil gas.

3.2 Well Siting and Construction

A general description of the criteria for siting a single central VW and associated VMPs are included in the protocol document. Figure 3.1 illustrates the proposed location of the central VW and VMPs at the Building 7705 site. The final

FIGURE 3.1



PROPOSED PILOT STUDY TEST AREA
BUILDING #7705
WESTOVER AFB, MASSACHUSETTS

DE268.37.02

ENGINEERING - SCIENCE

location of the VW may vary slightly from the proposed location if significant fuel contamination is not observed in the boring for the central VW. Based on site investigation data, the VW will be located approximately 100 feet east of Building 7705. A preliminary soil gas survey conducted by ES near Building 7705 showed low oxygen (i.e. < 1%), higher than normal carbon dioxide (i.e. > 2%), and high total volatile hydrocarbon levels (i.e. > 1000 parts per million) in the soil gas. The area is expected to have an average TPH concentration exceeding 2,000 mg/kg . Soils in this area are expected to be oxygen depleted (< 2%) and increased biological activity should be stimulated by oxygen-rich soil gas ventilation during full-scale operations.

Due to the relatively shallow depth of contamination at this site and the potential for moderate permeability soils, the radius of venting influence around the central air injection well in the pit is expected to exceed 40 feet. Three VMPs will be located within a 40-foot radius of the central VW. Background monitoring for this test will be conducted at an existing monitoring well (MW-36) used for background monitoring during the Battelle bioventing test in 1992.

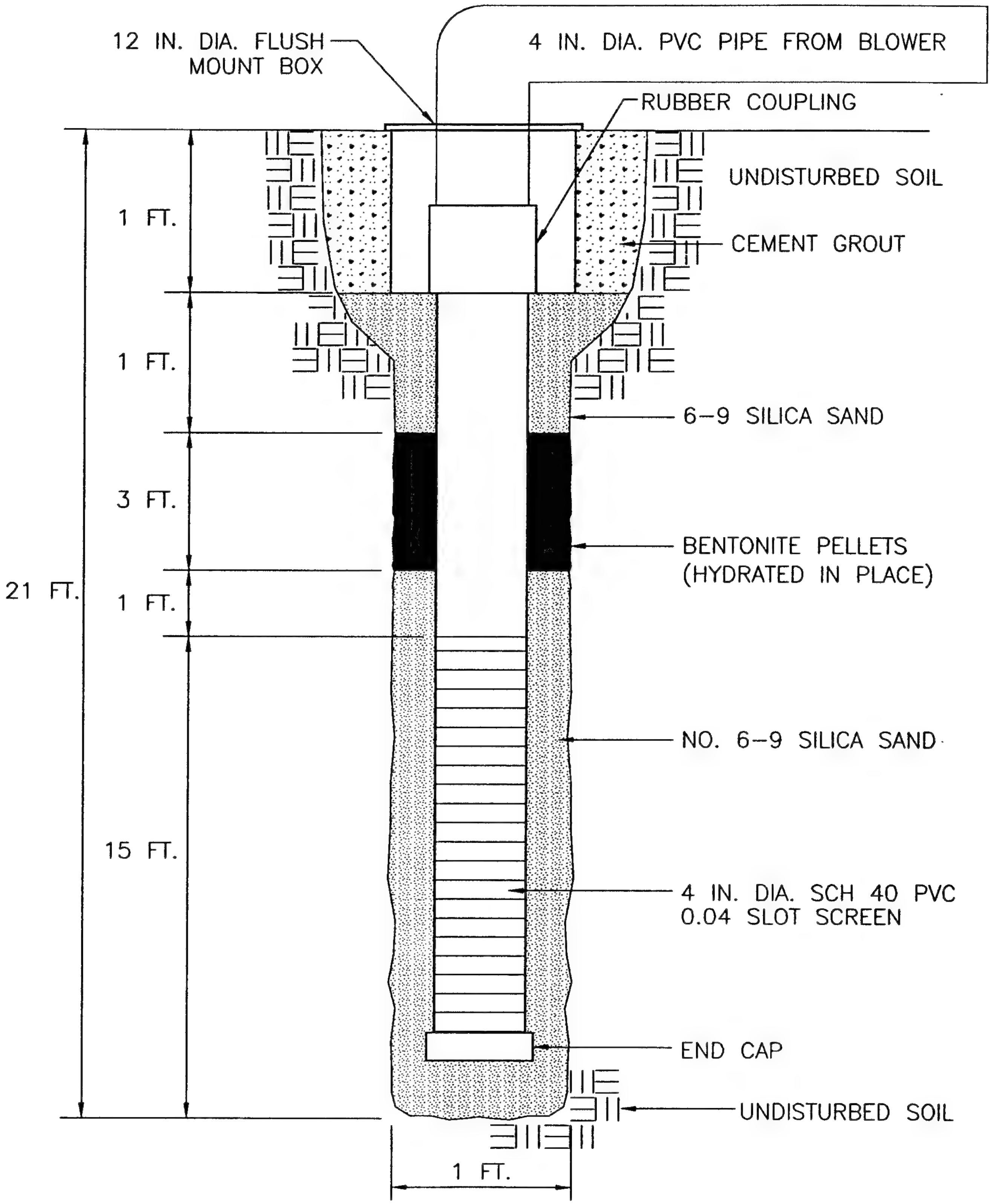
The VW will be constructed of 4-inch ID Schedule 40 PVC, with a 15 foot interval of 0.04 slotted screen set between 6 and 21 feet below ground surface (3 feet below the deepest seasonal groundwater elevation). Flush-threaded PVC casing and screen will be used with no organic solvents or glues. The filter pack will be clean, well-rounded silica sand with a 6-9 grain size and will be placed in the annular space of the screened interval. A 3-foot layer of bentonite will be placed directly over the filter pack. The bentonite will consist of granular bentonite and/or pellets placed in 6-inch lifts and hydrated in place with potable water to produce an air tight seal above the screened interval. A complete seal is critical to prevent injected air from short-circuiting to the surface during the bioventing test. Silica sand and cement grout will be placed over the pellets and extend to the ground surface. Figure 3.2 illustrates the proposed central VW construction details for this site.

A typical multi-depth VMP installation for this site is shown in Figure 3.3. Soil gas oxygen and carbon dioxide concentrations will be monitored at depth intervals of approximately 4 to 6 feet, 8 to 10 feet, and 12 to 14 feet at each location. Multi-depth monitoring will confirm that the entire soil profile is receiving oxygen and be used to measure fuel biodegradation rates at all depths. The annular space between these three monitoring points will be sealed with bentonite to isolate the monitoring intervals. Additional details on VW and monitoring point construction are found in Section 4 of the protocol document.

3.3 Handling of Drill Cuttings

Drill cuttings from all borings will be left on-site in accordance with CERCLA Guidance for Investigation Derived Waste (IDW). This guidance states that such IDW may be left at a site if the site is scheduled for remediation.

FIGURE 3.2



NOT TO SCALE

INJECTION VENTING WELL
CONSTRUCTION DETAIL

Westover AFB, Massachusetts

ENGINEERING-SCIENCE, INC.
Syracuse, New York

ES

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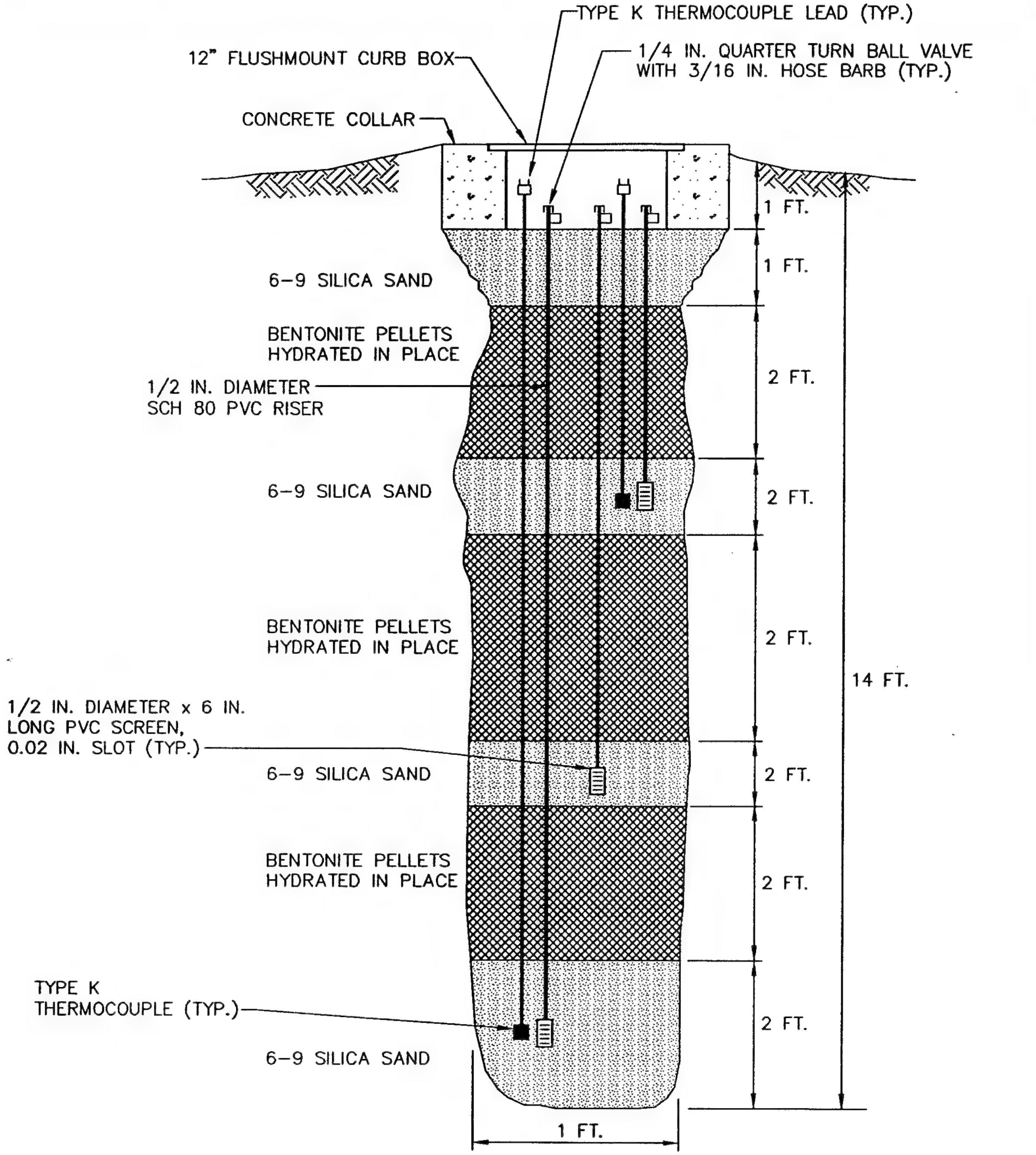
REVISED: 09/08/93

FIGURE 3.3



NOT TO SCALE

TYPICAL MONITORING POINT CONSTRUCTION DETAIL

Westover AFB, Massachusetts

ENGINEERING-SCIENCE, INC.
Syracuse, New York

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001631|D\DE268\BOLLING4.DWG

3.4 Soil and Soil Gas Sampling

3.4.1 Soil Sampling

Three soil samples will be collected from the pilot test area during the installation of the VWs and VMPs. One sample will be collected from the most contaminated interval of the central VW boring, and one sample will be collected from the interval of highest apparent contamination in each of the borings for two VMPs. Soil samples will be analyzed for TPH, BTEX, soil moisture, pH, particle sizing, alkalinity, total iron and nutrients.

Samples will be collected using a split-spoon sampler containing brass tube liners. A photoionization detector or total hydrocarbon vapor analyzer will be used to insure that breathing zone levels of volatiles do not exceed 1 ppm during drilling and to screen split spoon samples for intervals of high fuel contamination. Soil samples collected in the brass tubes will be immediately trimmed and aluminum foil and a plastic cap placed over the ends. Soil samples will be labelled following the nomenclature specified in the protocol document (Section 5.5), wrapped in plastic, and placed in an ice chest for shipment. A chain of custody form will be filled out and the ice chest shipped to the Pace, Inc., laboratory in Novato, California, for analysis. This laboratory has been audited by the U.S. Air Force and meets all quality assurance/quality control and certification requirements for the State of California.

3.4.2 Soil Gas Sampling

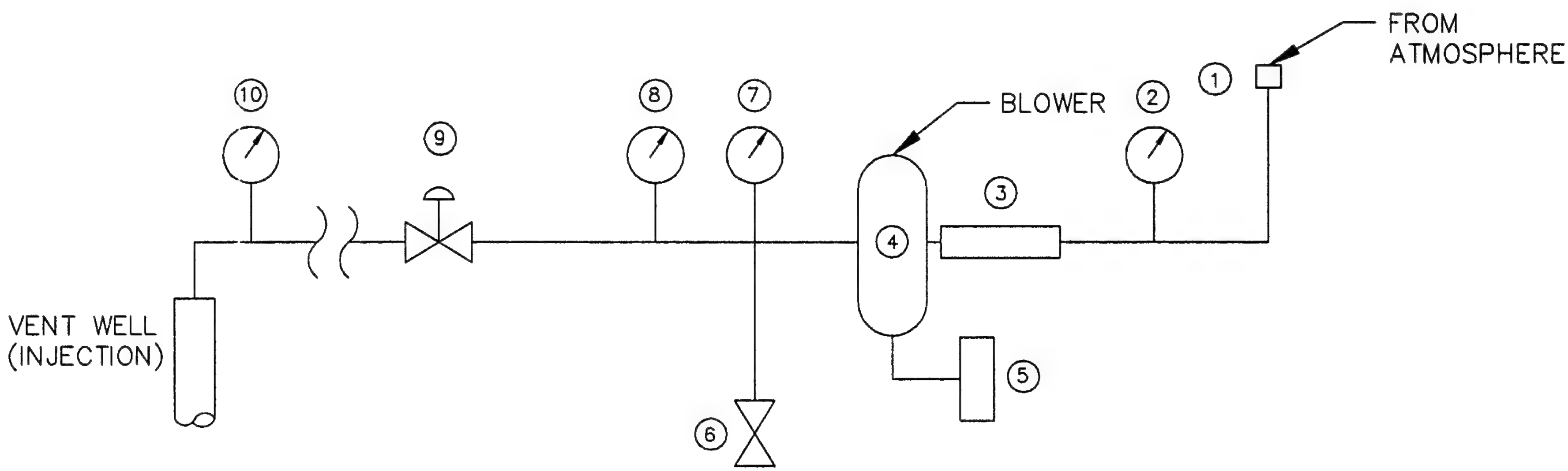
A total of three soil gas samples will be collected in SUMMA™ cannisters in accordance with the *Bioventing Field Sampling Plan* (ES, 1992). The samples will be collected from the VW and from the VMPs closest to and furthest from the VW at the site. These soil gas samples will be used to predict potential air emissions, to determine the reduction in BTEX and total volatile hydrocarbons (TVH) during the 1-year test, and to detect any migration of these vapors from the source area.

Soil gas sample canisters will be placed in a small cooler and packed with foam pellets to prevent excessive movement during shipment. Samples will not be sent on ice to prevent condensation of hydrocarbons. A chain-of-custody form will be filled out, and the cooler will be shipped to the Air Toxics laboratory in Folsom, California for analysis.

3.5 Blower System

A 1-HP regenerative blower capable of injecting 30 - 70 scfm will be used to conduct the initial air permeability test at the site. This blower provides a wide range of flow rates and should develop sufficient pressure to move air through moderate permeability soils. Figure 3.4 is a schematic of the air injection system that will be used for the pilot test in Building 7705. Air injection will be used to provide oxygen to soil bacteria and to minimize emissions of volatiles to the atmosphere. Based on ES experience with sandy soils similar to those at Westover AFB, we anticipate an air injection rate of 20 - 30 scfm will be sufficient for extended testing.

FIGURE 3.4



(1) INLET FILTER

(2) VACUUM GAUGE (INCHES OF H_2O)

(3) DRIVE MOTOR
1 HP / 3450 RPM @ 60 Hz / 230 v / SINGLE PHASE / 15 A

(4) BLOWER – GAST R4110-2 / REGENERATIVE
70 SCFM @ 20 INCHES H_2O

(5) POWER SWITCH

(6) AUTOMATIC PRESSURE RELIEF VALVE – SET @ 42 INCHES H_2O

(7) PRESSURE GAUGE (INCHES OF H_2O)

(8) THERMOMETER (FAHRENHEIT)

(9) MANUAL PRESSURE RELIEF (BLEED) VALVE – 1 1/2" BALL

(10) AIR VELOCITY MEASUREMENT PORT

SCHEMATIC OF BLOWER
SYSTEM FOR AIR INJECTION

Westover AFB, Massachusetts

ENGINEERING-SCIENCE, INC.
Syracuse, New York

ES

001631|D: \DE268\HANSCOM1.DWG

REVISED: 09/09/93

The maximum power requirement anticipated for this pilot test is a 230-volt, single-phase, 30-amp service. Additional details on power supply requirements are described in Section 5.0, Base Support Requirements.

3.6 Air Monitoring

The bioventing technique will minimize total emissions of more volatile hydrocarbons to the atmosphere. This is accomplished by reducing air injection rates to supply only the minimum required oxygen to sustain the indigenous microorganisms. By supplying only the required oxygen for biodegradation, volatilizations effects are minimized.

During all activities involving air injection, the air at the ground surface and at the breathing zone within a 20-foot radius of the injection well will be monitored for volatile hydrocarbons by use of a photoionization detector. Air monitoring will be done to ensure safe working conditions and to provide a rough estimate of volatilization loses, if they occur. More intense air monitoring is required during the first eight hours of the air permeability test because the potential for emission of the more volatile hydrocarbons is greatest at that time.

The potential for emissions at this site is minimal because the primary contaminant, JP-4, contains a minimal amount of volatile components, most of which should have volatilized through the sandy soils at the site. Flux emissions measured at a similar site at another Air Force base with similar contaminants and sandy soils showed less than 5 grams of fuel hydrocarbons emitted to the atmosphere per hour of operation, or less than 0.26 pounds per day.

3.7 In-Situ Respiration Test

The objective of the *in-situ* respiration test is to determine the rate at which soil bacteria degrade petroleum hydrocarbons. Respiration tests will be performed at the three VMPs with the highest apparent fuel contamination at the site. Air will be injected into each VMP depth interval containing low levels (<2%) of oxygen. A 20 to 24-hour air injection period will be used to oxygenate local contaminated soil. At the end of the air injection period, the air supply will be cut off, and oxygen and carbon dioxide levels will be monitored for five days or until the oxygen level falls below 5 %, whichever is earlier. The decline in oxygen and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals.

Concurrent to the air injection period, a conservative helium tracer will also be injected at the VMPs at a concentration of two to five percent. Helium levels will be monitored along with the oxygen and carbon dioxide levels to ensure that the VMPs do not leak. Additional details on the in-situ respiration test are found in Section 5.7 of the protocol document.

3.8 Air Permeability Test

The objectives of the air permeability test are to determine soil gas permeability and the extent of the subsurface that can be oxygenated using one air injection VW. Air will be injected into the 4-inch-diameter VW using the blower unit, and pressure response will be measured at each VMP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the

VMPs to verify that oxygen levels in the soil increase as the result of air injection. One air permeability test lasting 4 to 8 hours will be performed.

3.9 Installation of Extended Pilot Test Bioventing System

An extended, 1-year bioventing pilot system will also be installed at the Building 7705 site if the initial test results are positive. An existing power supply near the site will be used for the extended test. A licensed electrician subcontracted to ES will assist in wiring the blowers to line power. The blower will be housed in a small, prefabricated shed to provide protection from the weather. Additionally, the blower and all electrical equipment will be explosion proof.

The system will be in operation for 24-hours per day for 1 year. After 6 months and 12 months of operation, ES personnel will conduct follow-up *in-situ* respiration tests to monitor the long-term performance of this bioventing system. Weekly system checks will be performed by Westover AFB personnel. If required, major maintenance of the blower unit may be performed by ES personnel. Detailed blower system information and a maintenance schedule will be included in the operation and maintenance (O&M) manual provided to the base. More detailed information regarding the test procedures can be found in the protocol document.

4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

The procedures that will be used to measure the air permeability of the soil and *in-situ* respiration rates are described in Sections 4 and 5 of the protocol document. No exceptions to this protocol are anticipated.

5.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of a driller and the ES test team:

- Confirmation of regulatory approval for the pilot test.
- Assistance in obtaining a digging permit at each site.
- Provision of any paperwork required to obtain gate passes and security badges for approximately four ES employees and two drillers. Vehicle passes will be needed for two trucks and a drill rig.

During the initial three week pilot test the following base support is needed:

- Twelve square feet of desk space and a telephone in a building located as near to the site as practical.
- The use of a fax machine for transmitting 15 to 20 pages of test results.

Note: A generator supplied by ES will be used to provide power to the blower during the initial pilot test.

Prior to and during the one year extended pilot test the following base support is needed:

- Check the blower system at the site at least once a week to ensure that they are operating and to record the air injection pressure. ES will provide a brief training session on this procedure.

- Notify Mr. David Brown, ES-Syracuse, (315) 451-9560; or Mr. Jerry Hansen of AFCEE, (210) 536-5343, if the blower or motor stop working.
- Arrange site access for an ES technician to conduct *in-situ* respiration tests approximately six months and one year after the initial pilot test.

Note: ES will provide an electrical subcontractor to tap into the existing power supply.

6.0 PROJECT SCHEDULE

The following schedule is contingent upon timely approval of this pilot test work plan.

Event	Date
Draft Test Work Plan to AFCEE	13 September 1993
Submit Test Plan for Regulatory Approval	20 September 1993
Regulatory Approval To Proceed	4 October 1993
Begin Pilot Test	11 October 1993
Complete Initial Pilot Test	22 October 1993
Interim Results Report	3 December 1993
Six Month Respiration Test	April 1994
Final Respiration Test	October 1994

7.0 POINTS OF CONTACT

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Mr. David Brown
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290 Elwood Davis Road, Suite 312
Liverpool, New York 13088
(315) 451-9560/Fax (315) 451-9570

8.0 REFERENCES

Battelle, 1993. *Interim Report for Bioventing Field Initiative at Westover Air Force Base.* Chicopee, Massachusetts. February.

Engineering-Science, Inc. 1992. *Project Management Plan for AFCEE Bioventing,* Appendix D, Field Sampling Plan. Denver, Colorado. April.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* Columbus, Ohio. January.

PART II

DRAFT INTERIM TEST RESULTS REPORT FOR UNDERGROUND STORAGE TANKS AT BUILDING 7705 WESTOVER AFB, MASSACHUSETTS

Prepared for

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AFB, TEXAS

and

439TH CIVIL ENGINEERING SQUADRON
WESTOVER AFB, MASSACHUSETTS

by

Engineering-Science, Inc
290 Elwood Davis Road
Liverpool, New York

December 1993

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DRAFT INTERIM TEST RESULTS REPORTS FOR UNDERGROUND STORAGE TANKS AT BUILDING 7705 WESTOVER AFB, MASSACHUSETTS

An initial bioventing pilot test was performed at the Building 7705 site (Pump House) at Westover Air Force Base (AFB), Massachusetts during the period of 12 October 1993 to 27 October 1993. The purpose of this Part II report is to describe the results of the initial pilot tests and to make specific recommendations for extended testing to determine the long-term impact of bioventing to remediate site contaminants. Descriptions of the history, geology, and site contaminants are contained in Part I, the Test Work Plan.

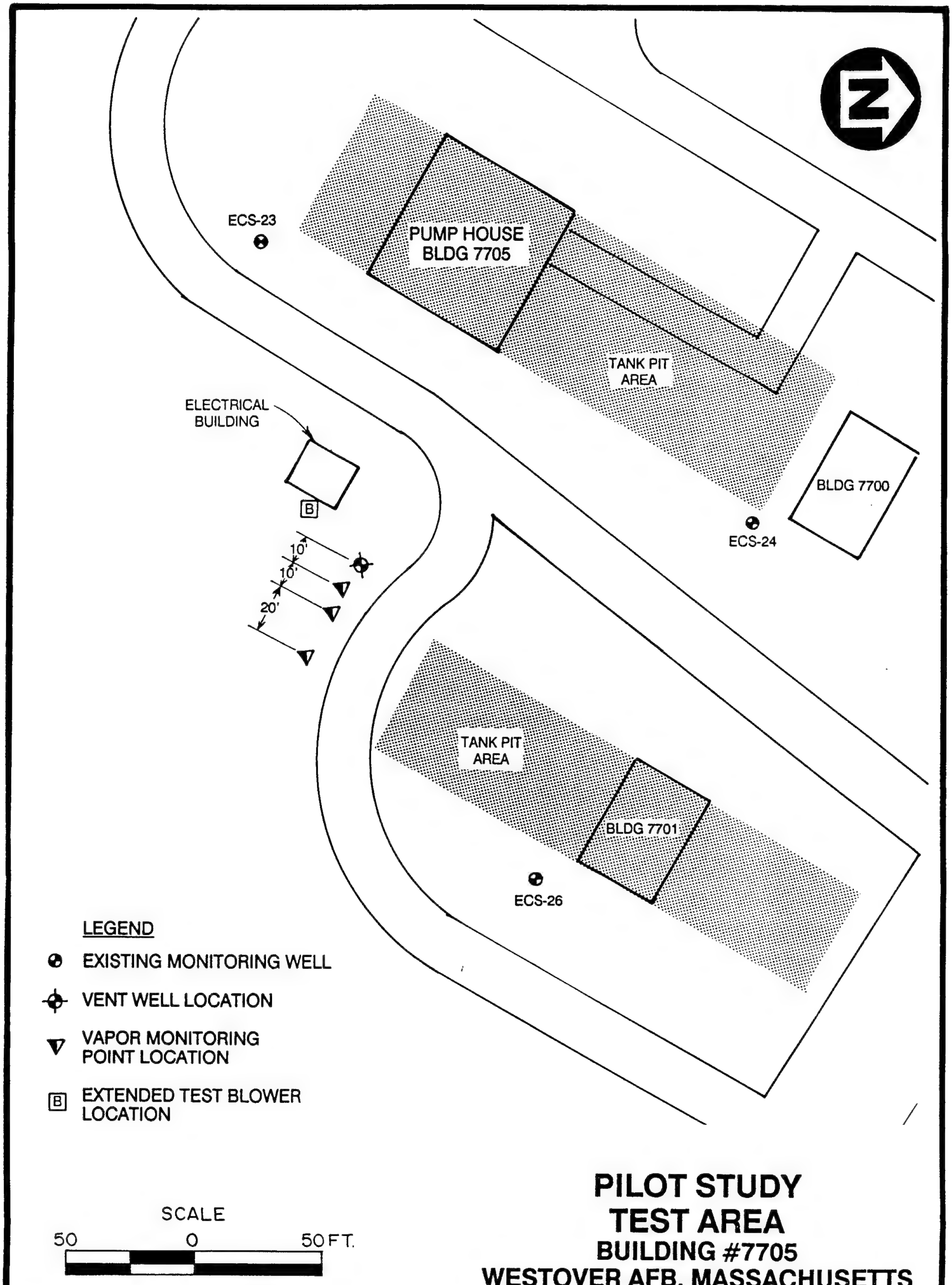
1.0 BUILDING 7705

1.1 Pilot Test Design and Construction

In accordance with the Test Work Plan, one vertical air injection vent well (VW) and three multiple-depth soil vapor monitoring points (VMPs) were installed the week of October 11, 1993. A 1-horsepower regenerative blower was installed at the VW to provide the necessary air for bioventing. Figure 1.1 depicts the locations of the VW, VMPs and blower at the Building 7705 site. Figure 1.2 depicts the vertical hydrogeologic cross section around Building 7705. The following sections describe in more detail the final design and installation of the bioventing system.

1.2 Vent Well Construction

The VW was installed on October 12, 1993 in an area of documented high TPH contamination. The VW was constructed of 4-inch diameter Schedule 40 PVC with a slot size of 0.04 inches. The total depth of the VW was 21 feet below ground surface (bgs), with a screened interval from 21 to 6 feet bgs. The annular space between the well casing and the borehole was filled with 6-9 silica sand from the bottom of the boring to approximately five feet bgs. Granular bentonite was placed above the sand pack from five feet bgs to two feet bgs and hydrated in place with potable water. A one-foot layer of 6-9 silica sand was placed over the bentonite layer. The VW was finished with a one foot layer of cement/bentonite grout and a 12-inch flushmount protective well cover. The well cover was cemented in place with the cement/bentonite grout. A detail of the VW construction is presented on Figure 1.3.



PILOT STUDY
TEST AREA
BUILDING #7705
WESTOVER AFB, MASSACHUSETTS

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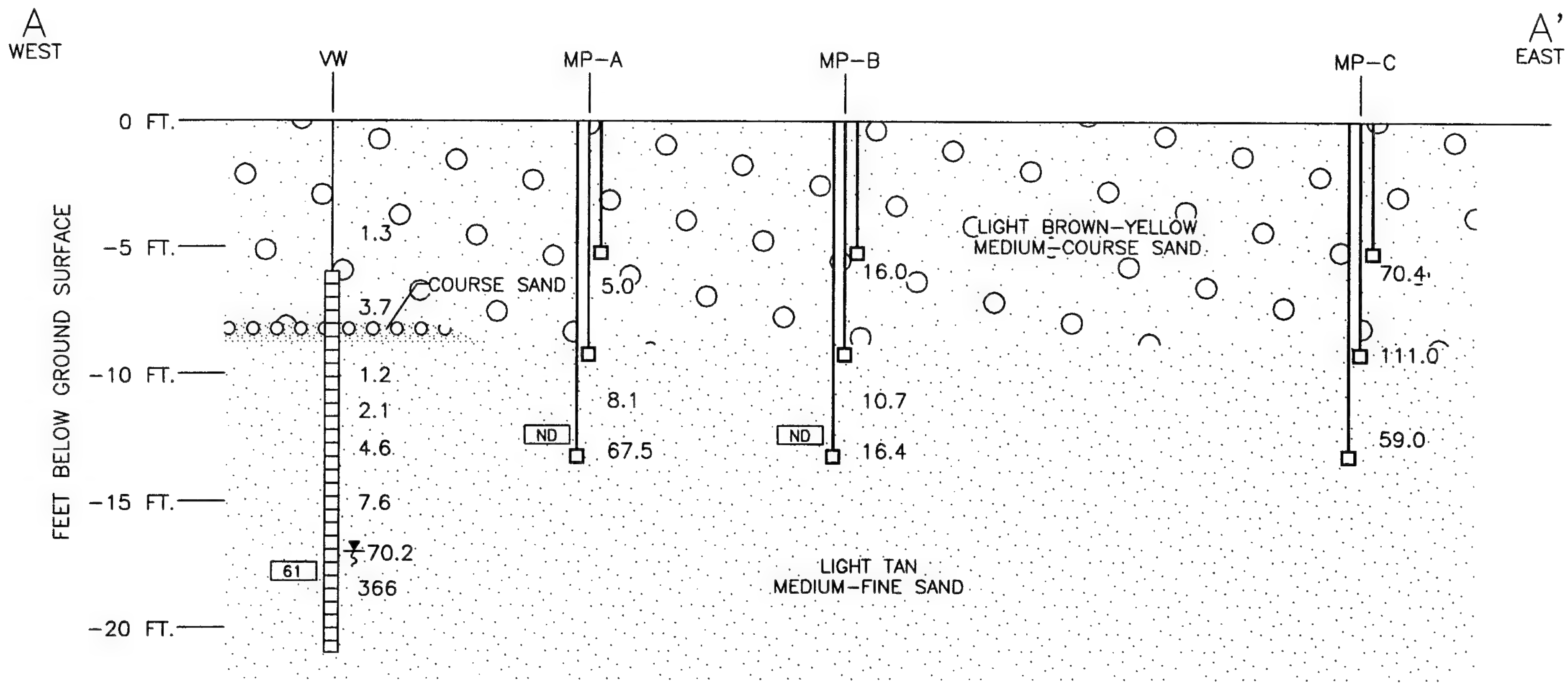


LEGEND

GROUNDWATER LEVEL	
MONITORING POINT	
AIR INJECTION WELL	
SCREEN INTERVAL	
5.0	FIELD SCREENING RESULTS FOR TOTAL VOLATILE HYDROCARBONS (ppmv)
44	LABORATORY RESULTS FOR SOIL TOTAL PETROLEUM HYDROCARBONS (PPM)
VW	VENT WELL
MP–A	MONITORING POINT

5' 2.5' 0 5'

Approximate Scale in Feet

HORIZONITAL AND VERTICAL

REVISED 12/22/93
001631|D:\DE268\WEST001.DWG

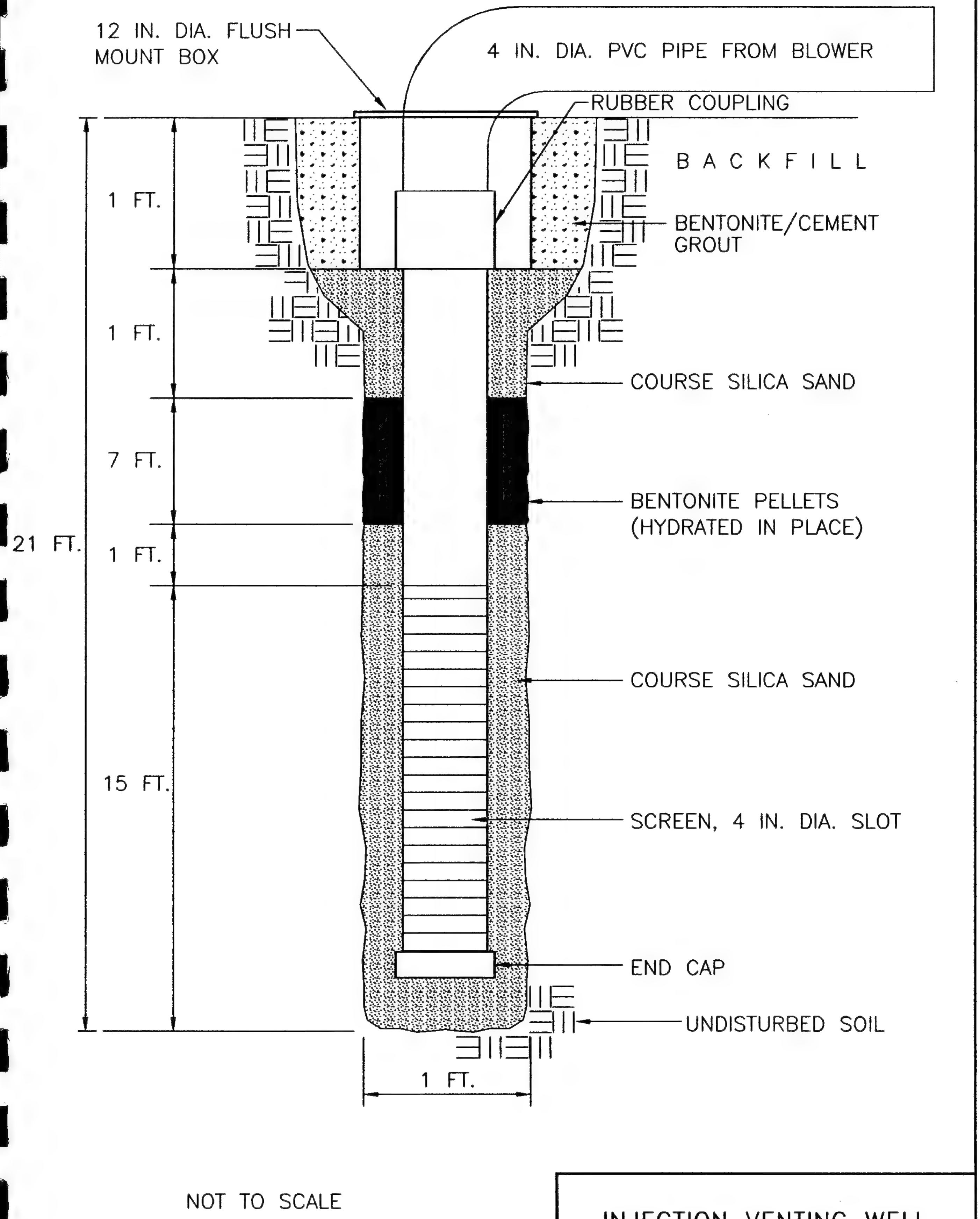
GEOLOGIC PROFILE BIOVENTING SITE 2 BUILDING 7705

WESTOVER AFB, MASSACHUSETTS

ENGINEERING–SCIENCE, INC.
Syracuse, New York

FIGURE 1.2

FIGURE 1.3



INJECTION VENTING WELL CONSTRUCTION DETAIL

Westover AFB, Massachusetts

ENGINEERING–SCIENCE, INC.
Syracuse, New York

001631|D:\DE268\PEASE3.DWG

REVISED: 12/09/93

1.3 Soil Vapor Monitoring Points

Three soil vapor monitoring points (VMPs) were installed at 10, 20 and 40 feet radially away from the air injection vent well. Each VMP was constructed to provide multiple depth soil gas monitoring with three discrete sample points at 13.5, 9.5 and 5.5 feet bgs. Each discrete point was constructed of a six-inch long piece of 1/2-inch diameter Schedule 40 PVC well screen with 0.02 slot size. The riser of each discrete point was constructed of 1/2-inch Schedule 80 PVC, which extended to approximately six inches bgs.

Clean 6-9 silica sand was placed around each discrete point to provide a filter pack between the borehole wall and the point. Granular bentonite was placed both below and above each discrete point to provide an air tight seal between the points. The bentonite was placed in 12-inch lifts and hydrated in place to assure the proper seal. The top of each discrete point riser was fitted with a 1/4-inch quarter turn ball valve and 3/16-inch hose barb to allow for connection of appropriate monitoring instruments.

Additionally, Type K thermocouples with mini connectors were installed at the 13.5 feet and 5.5 feet bgs discrete monitoring points in the VMP closest to the VW (MPA). These thermocouples will be used to measure the temperature profile at the site. The top of each VMP was completed with a 12-inch flush mounted protective well cover set in a concrete base. Figure 1.4 shows the construction of the soil vapor monitoring points.

1.4 Blower Unit Installation

A 1-horsepower GAST® regenerative blower unit was installed at the Building 7705 site for the initial and extended pilot tests. The blower was installed in a weather resistant enclosure and electrically wired for permanent 240-volt, 30-amp service. Air from the blower is injected into the vent well via a two inch PVC line connected to the blower's exhaust port. A diagram of the blower unit and installation is presented on Figure 1.5.

Prior to departing the site, the ES engineer provided an operations and maintenance briefing, O&M checklist, and blower maintenance manual to the base point of contact. A copy of the O&M checklist is provided in Appendix A.

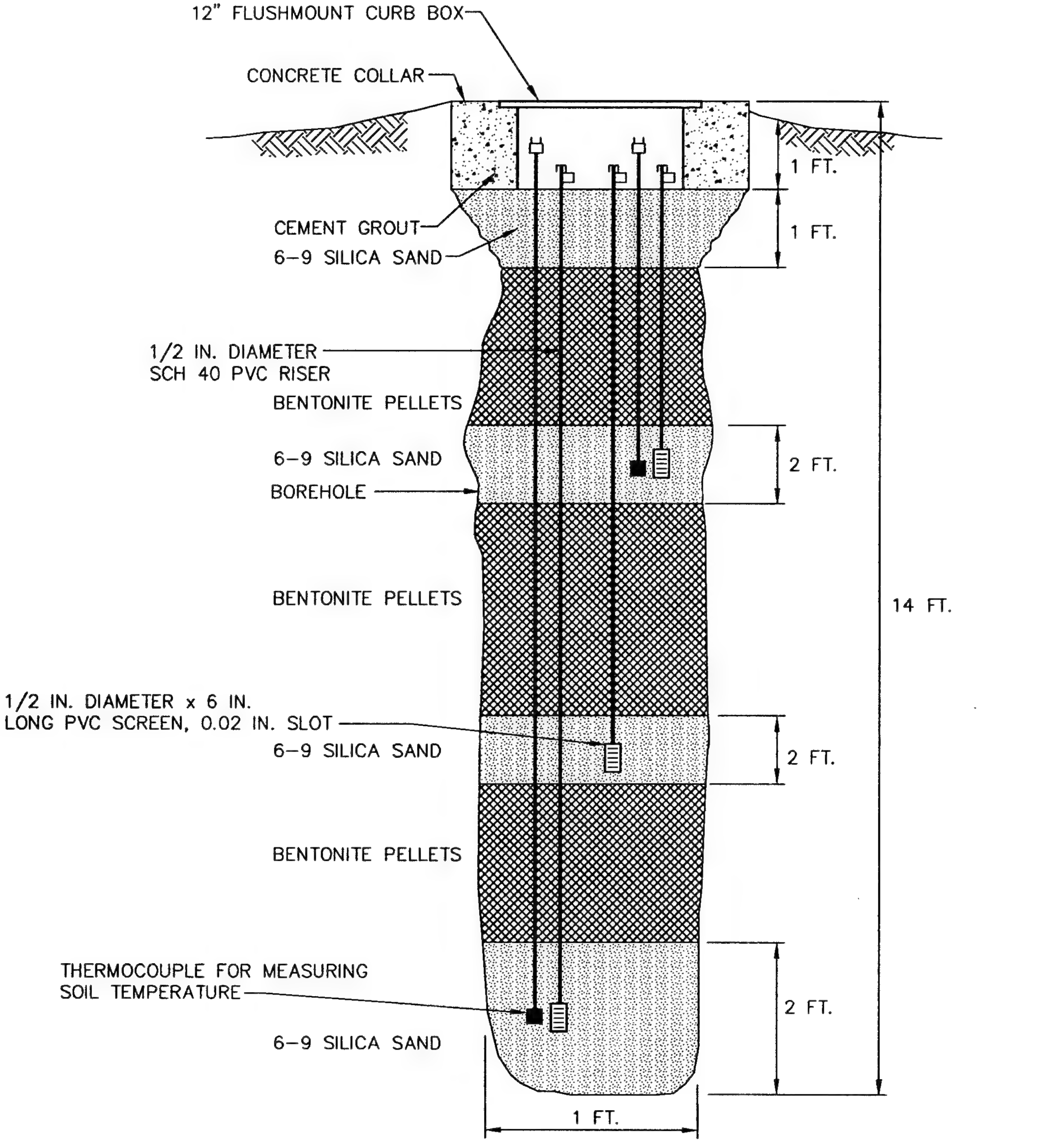
2.0 PILOT TEST SOIL AND SOIL GAS SAMPLING RESULTS

2.1 Soil and Soil Gas Sampling Results

Soils at the Building 7705 site consist of fine to medium light brown to tan sand. This soil profile was consistent throughout the unsaturated zone. Groundwater was encountered at approximately 17 feet bgs

Hydrocarbon contamination at the site appears to extend from the ground surface to the groundwater table. Contaminated soils collected by split spoons during the VW and VMP installations were identified based on visual appearance, odor and photoionization detector (PID) screening. Strongest odors and staining were noted in the samples collected immediately above the groundwater table. PID readings ranged from 1.2 parts per million (ppm) to 366 ppm

FIGURE 1.4



NOT TO SCALE

TYPICAL MONITORING POINT CONSTRUCTION DETAIL

WESTOVER AFB, MASSACHUSETTS

ENGINEERING-SCIENCE, INC.
Syracuse, New York

ES

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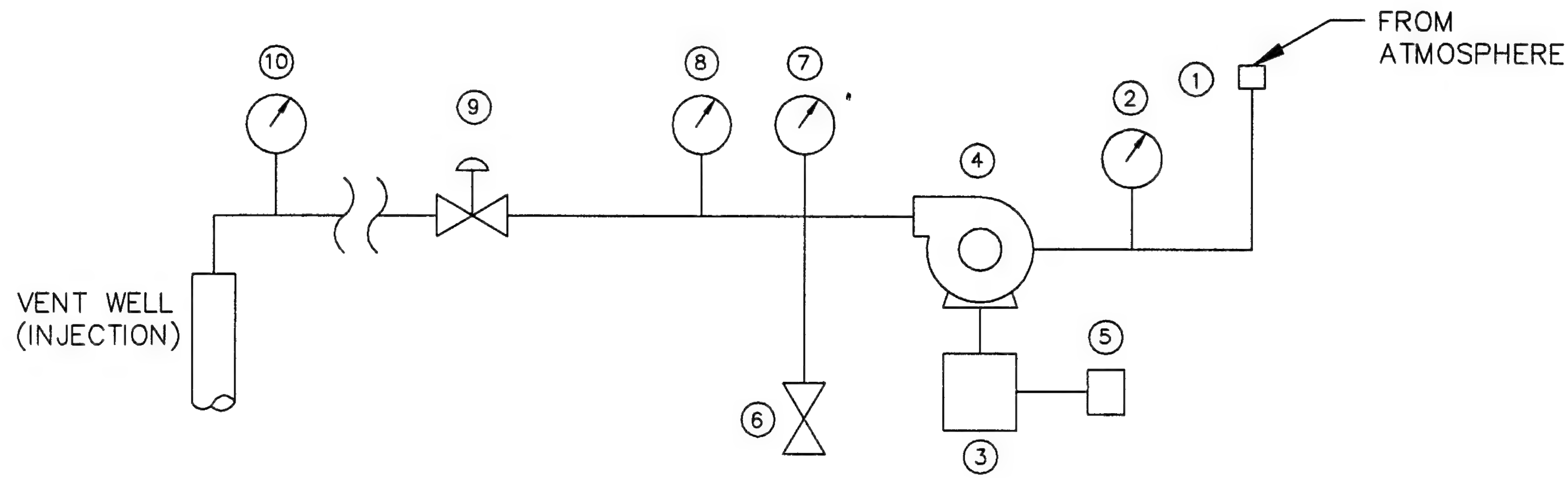
REVISED: 12/22/93



(1) INLET FILTER

(2) VACUUM GAUGE – INCHES OF H20

(3) DRIVE MOTOR
1 HP / 3450 RPM @ 60 Hz / 230 v / SINGLE PHASE / 15 A

(4) BLOWER – GAST R411D-2 REGENERATIVE
70 SCFM @ 20 INCHES H_2O

(5) POWER SWITCH

(6) AUTOMATIC PRESSURE RELIEF VALVE – SET @ 6 psig

(7) PRESSURE GAUGE (INCHES OF H20)

(8) THERMOMETER (FAHRENHEIT)

(9) MANUAL PRESSURE RELIEF (BLEED) VALVE – 1 1/2" BALL

(10) AIR VELOCITY MEASUREMENT PORT

001631|D:\DE268\SAWR35.DWG

REVISED: 12/22/93

SCHEMATIC OF BLOWER
SYSTEM FOR AIR INJECTION

WESTOVER AFB, MASSACHUSETTS

ENGINEERING-SCIENCE, INC.
Syracuse, New York

FIGURE 1.5

Soil samples for laboratory analysis were collected in stainless steel split spoons during the VW and VMP installations. Procedures for soil sample collection specified in the Protocol Document (Hinchee, et. al., 1992) were followed for all sample collections. Samples were collected from the 18-20 feet interval from the VW, from the 12-14 feet interval in MPA, and from the 8-10 feet interval in MPC. All split spoon samples were field screened for VOCs by use of the PID to determine the presence of hydrocarbon contamination and to select samples for laboratory analysis.

Soil gas samples were collected immediately following the air permeability test in laboratory provided, evacuated SUMMA® canisters. Soil gas samples were collected from the VW, the 13.5 feet bgs discrete monitoring point at MPA, and from the 13.5 feet bgs discrete monitoring point in MPC. All soil gas samples were collected following procedures in the Protocol Document.

The soil samples for laboratory analysis were placed on ice and shipped via Federal Express® to the PACE Inc., Laboratory in Novato, CA. Each soil sample was analyzed for total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethylbenzene, and xylenes (BTEX); iron; alkalinity; total Kjeldahl nitrogen (TKN); pH; phosphates; percent moisture; and grain size distribution. Soil gas samples were placed in a shipping box (without ice), and shipped via Federal Express® to Air Toxics, Inc., in Folsom, CA for total volatile hydrocarbon (TVH) and BTEX analysis. The results of the soils and soil gas samples are presented in Table 2.1.

2.2 Exceptions to Test Protocol Document Procedures

No exceptions to the Test Protocol Document procedures were conducted during the initial pilot test at Building 7705.

2.3 Field QA/QC Results

Field quality assurance/quality control (QA/QC) samples were not collected or required at this site because the five percent collection requirement for QA/QC duplicate samples has been met at other AFCEE bioventing test sites.

3.0 PILOT TEST RESULTS

3.1 Initial Soil Gas Chemistry

Prior to initiating any air injection, soil gas in the VW and all VMPs was monitored for TVH, oxygen, and carbon dioxide. The VW and VMPs were purged to remove stale soil gas prior to monitoring. Soil gas monitoring was accomplished using portable gas analyzers as described in the Protocol Document. The results of the initial monitoring are presented in Table 3.1.

As shown in Table 3.1, the VW and all VMPs exhibited depleted oxygen levels (2.7 % to 8.7 %), elevated carbon dioxide readings (greater than 6 %), and TVH readings ranging from 300 ppm to 7,400 ppm. These readings suggest that the indigenous microorganisms have depleted much of the naturally available oxygen supply and indicate the presence of significant biological activity.

TABLE 2.1
SOIL AND SOIL GAS LABORATORY ANALYTICAL RESULTS
BUILDING 7705
Westover AFB, Massachusetts

Analyte (Units)[a]	Sample Location – Depth (feet below ground surface)		
Soil Gas Hydrocarbons	WE2–VW	WE2–MPA–13.5	WE2–MPC–13.5
TPH (ppmv)	2.7	2.3	270
Benzene (ppmv)	ND	ND	ND
Toluene (ppmv)	ND	ND	ND
Ethylbenzene (ppmv)	0.001	0.001	0.36
Xylenes (ppmv)	0.014	0.017	0.23
Soil Hydrocarbons	WE2–VW–18	WE2–MPA–12	WE2–MPC–8
TRPH (mg/kg)	61	ND	ND
Benzene (mg/kg)	ND	ND	ND
Toluene (mg/kg)	1.4	0.0007	ND
Ethylbenzene (mg/kg)	ND	ND	ND
Xylenes (mg/kg)	2.2	0.0034	ND
Soil Inorganics			
Iron (mg/kg)	4680	5090	5070
Alkalinity (mg/kg as $CaCO_3$)	ND	ND	ND
pH (units)	6.9	7.3	6.1
TKN (mg/kg)	67	500	31
Phosphates (mg/kg)	160	190	230
Soil Physical Parameters			
Soil Temperature (°F 5.5' & 13.5')	NS	59.3 & 61.3	NS
Moisture (% wt.)	11	14	4.4
Gravel (%)	5	4	12.2
Sand (%)	93.2	94	85.5
Silt (%)	1	1.2	1.5
Clay (%)	0.8	0.8	0.7

[a] TRPH = total recoverable petroleum hydrocarbons; TPH = total petroleum hydrocarbons; mg/kg = milligrams per kilogram; ppmv = parts per million by volume; $CaCO_3$ = calcium carbonate; TKN = total kjeldahl nitrogen.

ND Not detected.

NS Not sampled.

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TABLE 3.1
INITIAL SOIL GAS CHEMISTRY
BUILDING 7705
Westover AFB, Massachusetts

MP Depth (ft)	O_2 (%)	CO_2 (%)	TVH (ppm)
WE2-VW	7.7	6.7	400
WE2-MPA-5.5	8.7	6.1	300
WE2-MPA-9.5	7.7	6.7	360
WE2-MPA-13.5	7.0	7.0	350
WE2-MPB-5.5	6.2	6.7	380
WE2-MPB-9.5	5.1	7.4	560
WE2-MPB-13.5	4.5	7.8	800
WE2-MPC-5.5	3.2	7.6	820
WE2-MPC-9.5	2.7	7.8	5,000
WE2-MPC-13.5	2.7	8.0	7,400

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3.2 Air Permeability

An air permeability test was conducted according to the Protocol Document procedures on 27 October 1993. Air was injected into the VW for four hours at a rate of approximately 20 cubic feet per minute (cfm) and an average pressure of seven inches of water. Steady-state pressure levels were achieved at all MPs in less than approximately six minutes. Table 3.2 provides the maximum steady-state pressures at each discrete monitoring point. Based on this data, the site soils have an air permeability of 83 to 938 darcy units. This is typical of highly permeable sandy soils.

3.3 Oxygen Influence

Table 3.3 shows the increases in soil gas oxygen that resulted from the 4 hours of air injection at the VW. The depth and radius of oxygen influence in the subsurface resulting from air injection into the central VW is the primary design parameter for bioventing systems. Optimization of full-scale and multiple VW systems require pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and vent well screen configuration. Based on oxygen increases at all depths at MPC, the radius of oxygen influence is expected to exceed 40 feet with an air injection rate of 20 cfm at this site.

3.4 In-Situ Respiration Rates

In-situ respiration tests were performed at the VW and at monitoring point MPC at depths of 9.5 and 13.5 feet bgs. The VW was selected because a smear zone was observed at the water table interface. The MPC points were chosen based on their low oxygen readings (2.7 %), high carbon dioxide readings (greater than 7 %), and high TVH readings (greater than 2,500 ppm). A 4.2 percent helium in air mixture was injected into each of the three discrete monitoring points for 20 hours during the initial part of the in-situ respiration test. Oxygen, carbon dioxide, and TVH concentrations were then measured in the soil gas at each discrete monitoring point. These readings were collected for approximately 95 hours following cessation of the helium/air injection period. The measured oxygen losses were then used to calculate biological oxygen utilization rates. The results of the in-situ respiration testing for the VW and MPC points are presented in Figures 3.1 through 3.3, and Table 3.4 provides a summary of the calculated oxygen utilization rates.

Because helium is a conservative, inert gas, the change in helium concentration over time can be useful in determining the effectiveness of the bentonite seals between each discrete monitoring point in the MPs. Figures 3.1 through 3.3 compare oxygen utilization and helium retention. As shown on these figures, the loss of helium from the soil was approximately the same as the steady state rate of oxygen utilization. Because helium will diffuse into a given medium approximately three times faster than oxygen due to helium's lower molecular weight, the measured oxygen loss is primarily the result of bacterial respiration. However, it does appear that a portion of the oxygen loss was due to diffusion in these porous, sandy soils.

TABLE 3.2
MAXIMUM PRESSURE RESPONSE
AIR PERMEABILITY TEST
BUILDING 7705
Westover AFB, Massachusetts

	Distance from injection well (WE2–VW)								
	10' (MPA)			20' (MPB)			40' (MPC)		
Depth (feet)	5.5	9.5	13.5	5.5	9.5	13.5	5.5	9.5	13.5
Time (minutes)	1	3	3	4	0	7	1	0	3
Max Pressure (inches H_2O)	0.4	0.3	0.3	0.17	0	0.19	0.1	0	0.1

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TABLE 3.3
INFLUENCE OF AIR INJECTION AT VENT WELL ON MONITORING POINT OXYGEN LEVELS
BUILDING 7705
Westover AFB, Massachusetts

MP	Distance From VW (ft)	Depth (ft)	Initial O_2 (%)*	Final O_2 (%) Permeability Test
WE2-MPA-5.5	10	5.5	8.7	19.5
WE2-MPA-9.5	10	9.5	7.7	14.0
WE2-MPA-13.5	10	13.5	7.0	18.0
WE2-MPB-5.5	20	5.5	6.2	10.9
WE2-MPB-9.5	20	9.5	5.1	8.2
WE2-MPB-13.5	20	13.5	4.5	20.0
WE2-MPC-5.5	40	5.5	3.2	10.1
WE2-MPC-9.5	40	9.5	2.7	7.5
WE2-MPC-13.5	40	13.5	2.7	7.6

* Initial readings prior to respiration test

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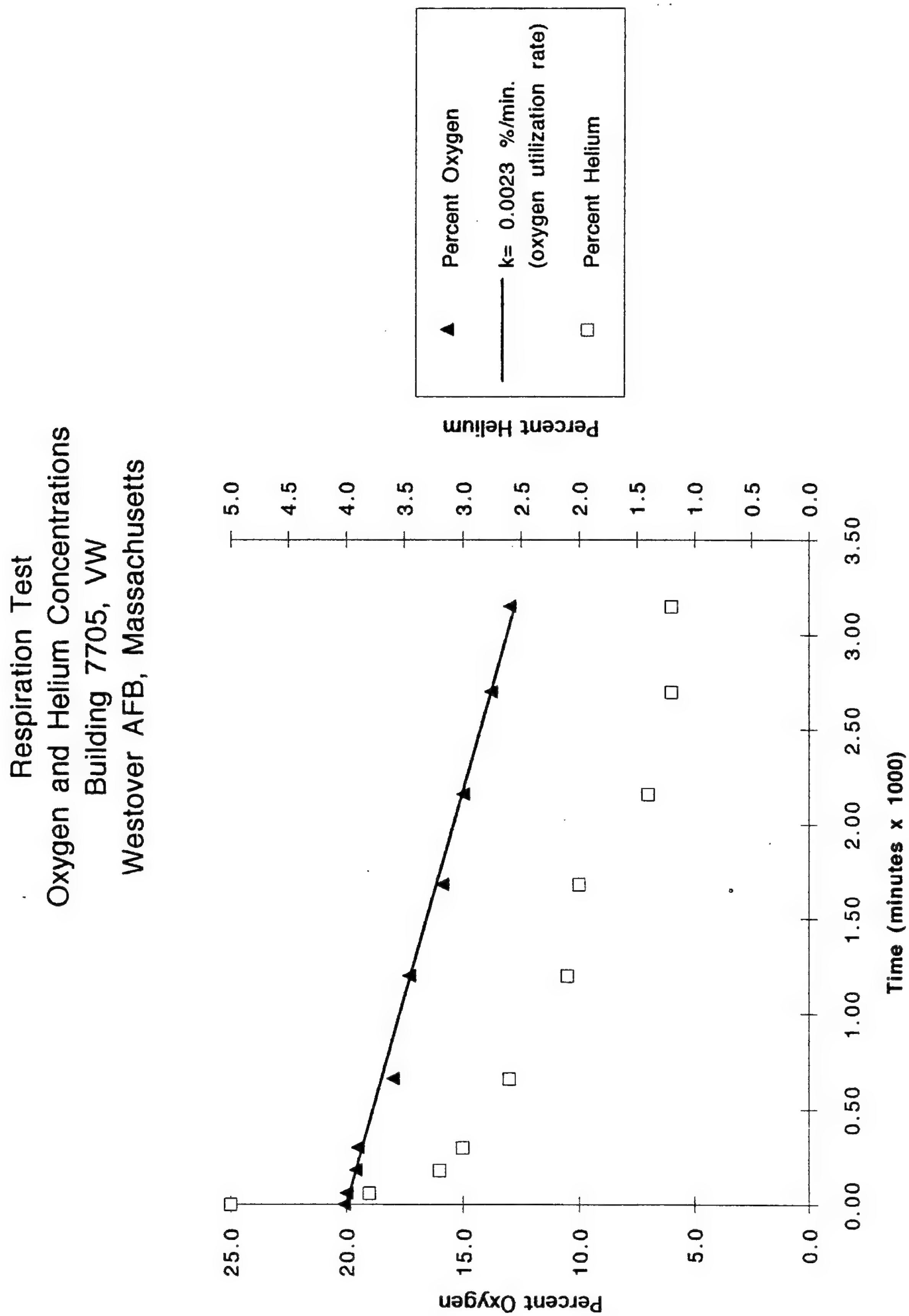
Figure 3.1



Respiration Test
Oxygen and Helium Concentrations
Building 7705, VW
Westover AFB, Massachusetts
Percent Oxygen
k= 0.0023 %/min.
(oxygen utilization rate)
Percent Helium
Time (minutes x 1000)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
0.0
5.0
10.0
15.0
20.0
25.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

Figure 3.2

Respiration Test
Oxygen and Helium Concentrations
Building 7705, MPC-8.5
Westover AFB, Massachusetts

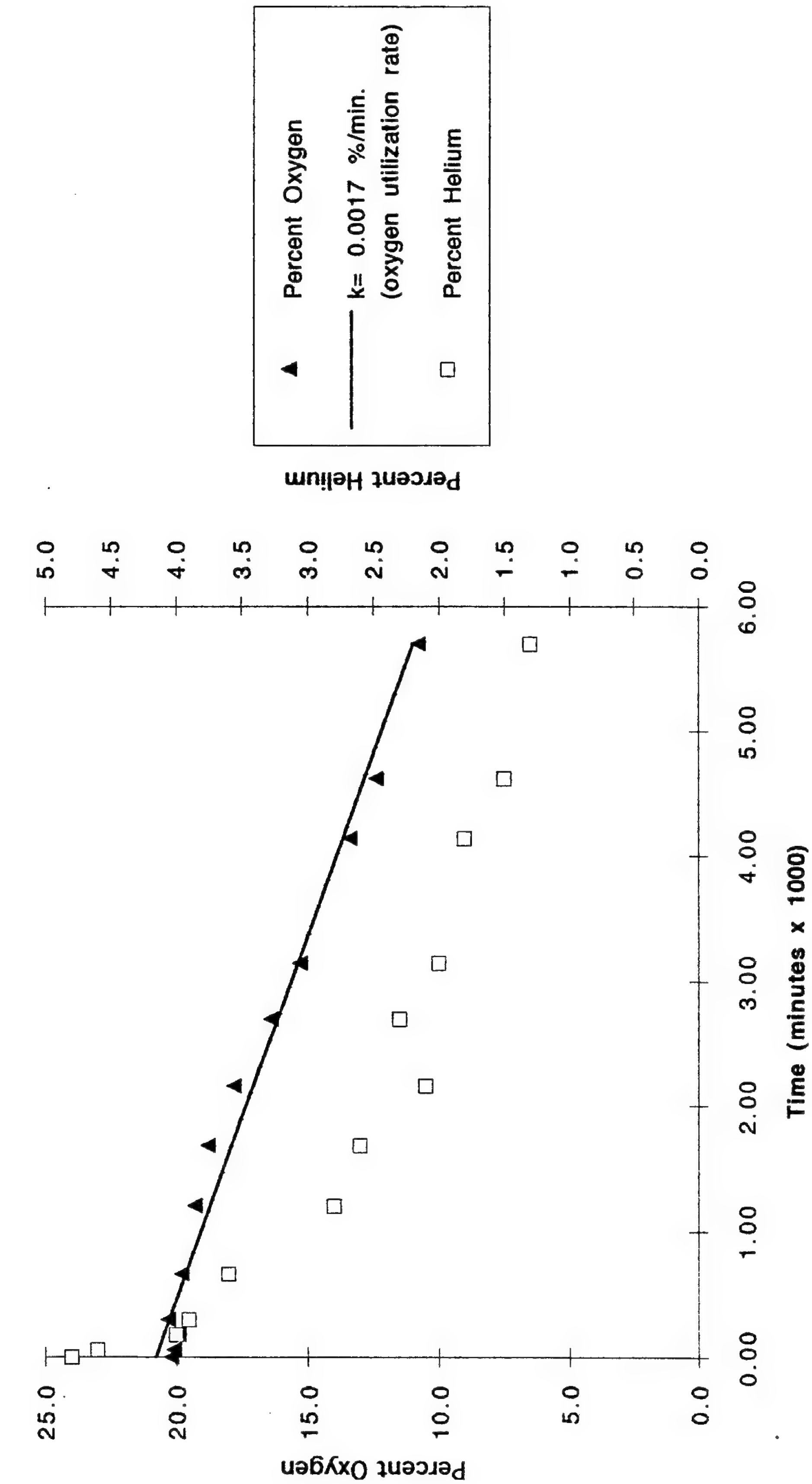


Figure 3.3

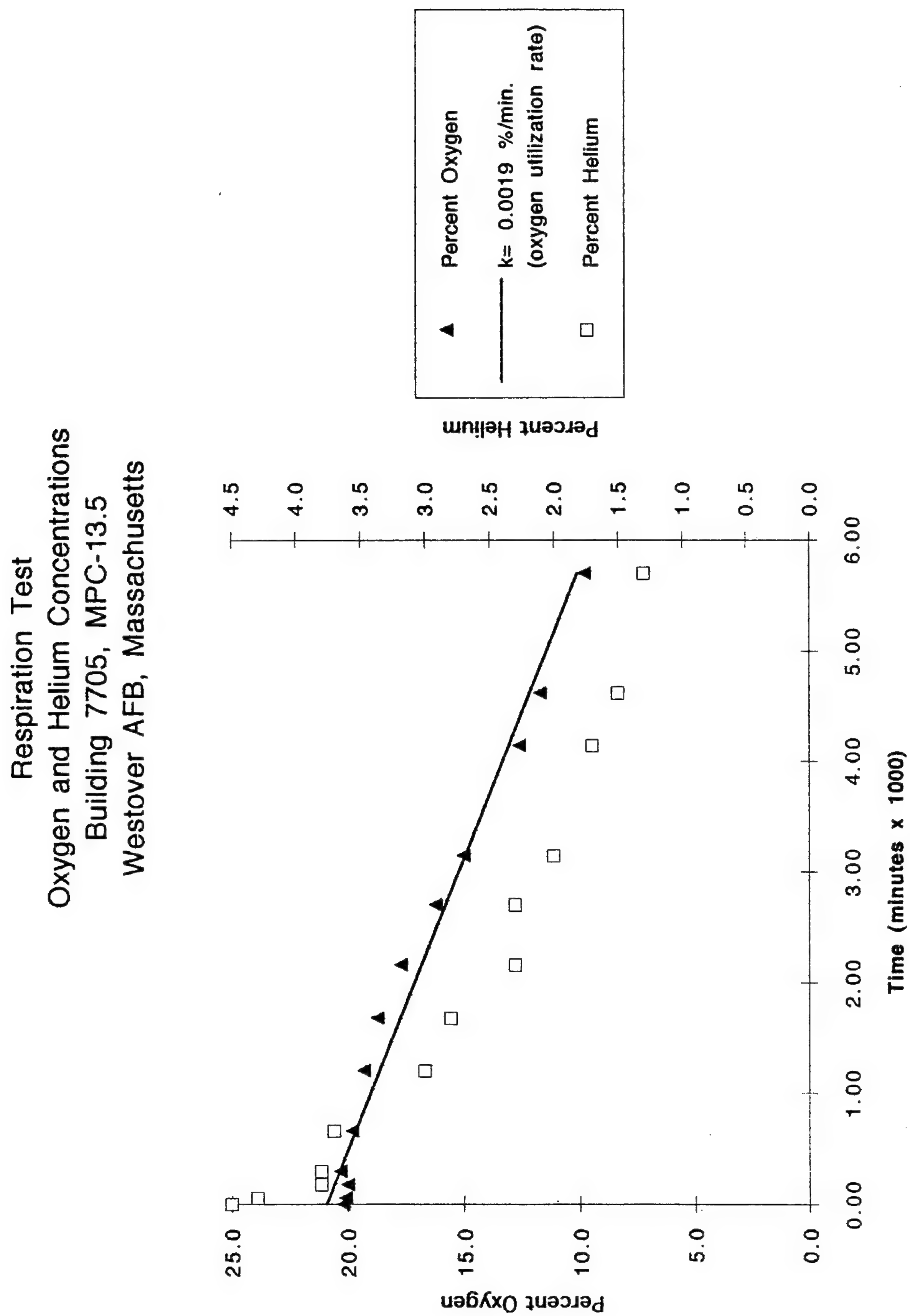

Respiration Test
Oxygen and Helium Concentrations
Building 7705, MPC-13.5
Westover AFB, Massachusetts
Percent Oxygen
k= 0.0019 %/min.
(oxygen utilization rate)
Percent Helium
Percent Helium
Percent Oxygen
Time (minutes x 1000)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
0.0
5.0
10.0
15.0
20.0
25.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

TABLE 3.4
OXYGEN UTILIZATION RATES
BUILDING 7705
Westover AFB, Massachusetts

	O_2 Loss[1] (%)	Test Duration (min)	O_2 Utilization[1] Rate (% per min)
VW	8.4	5700	0.0023
MPC–8.5	9.4	5700	0.0017
MPC–13.5	10.4	5700	0.0019

[1] Values based on linear regression (Figures 3.1 through 3.3)

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Based on the results of the respiration test, an estimated 390 mg of fuel per kilogram of soil can be biodegraded each year at the Building 7705 site. This value is the average of the fuel consumption rates calculated for every point at which a respiration test was conducted. The interval-specific fuel consumption rates were calculated using observed oxygen utilization rates (Table 3.4), estimated air filled porosities, and a conservative ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. The air filled porosity calculated for each test point ranged from 0.055 to 0.15 liter air per kilogram of soil.

3.5 Potential Air Emissions

The long-term potential for air emissions from full-scale bioventing operations at Building 7705 are considered to be low because of the type of the site contaminants, primarily JP4 jet fuel, which contains a minimal concentration of volatile compounds. Additionally, a recent ground surface emission flux test was conducted at a similar site at another Air Force base with similar contaminants and soil type. Results of this test showed an emission rate of less than 0.002 pounds of benzene per day. Health and safety monitoring conducted during the four hour permeability test using a photoionization detector sensitive to 1 ppm did not detect any hydrocarbons either in the breathing zone or at the ground surface. Because the potential for air emissions is highest during the initial air injection period, and no emissions were detected, the long-term air emission potential is considered low.

4.0 RECOMMENDATIONS

Initial bioventing test at Building 7705 indicate that naturally occurring oxygen has been depleted in the contaminated soils, and that air injection will be an effective method of increasing aerobic fuel biodegradation. AFCEE has recommended that air injection begin at Building 7705 to determine the long-term radius of oxygen influence and the effects of time, available nutrients and changing temperatures on fuel biodegradation rates.

A 1 horsepower regenerative blower has been installed at Building 7705 to inject air at a rate of 20 cfm. This size blower was installed to allow for expansion of the bioventing system to include multiple air injection vent wells to impact an even larger area if necessary in the future. After the one-year test period is begun, ES will return to the base at six months and one year to analyze the soil gas and conduct follow-up in-situ respiration tests. Additionally, at the one year point, ES will collect soil samples from the Building 7705 area to determine the soil contamination levels after one year of in-situ treatment.

Based on the results of the first year of pilot-scale bioventing, AFCEE will recommend one of three options for the Building 7705 site:

1. Upgrade, if necessary, and continue operation of the bioventing system.
2. If the one year soil samples indicate that significant contamination removal has occurred. AFCEE may recommend additional soil sampling to confirm that the cleanup criteria has been achieved.

3. If significant difficulties or poor results are encountered during the bioventing pilot test, AFCEE may recommend removal of the blower system and proper abandonment of the VW and MPs.

5.0 REFERENCES

Engineering-Science, Inc. 1993. *Draft Bioventing Test Work Plan for Underground Storage Tanks at Building 7705 Westover AFB, Massachusetts*. September.

Hinchee, R.E., Ong, S.K., Miller, R.N., Downey, D.C., Frandt, R. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* Columbus, Ohio. January.

APPENDIX A

OPERATION AND MAINTENANCE WEEKLY CHECK LIST

REGENERATIVE BLOWER
INJECTION SYSTEM DATA COLLECTION SHEET

SITE:________

DATE	TIME	INLET VACUUM (IN. WATER)	OUTLET TEMP. (DEGREES F)	OUTLET PRESSURE (IN. WATER)	BLOWER FUNCTIONING UPON ARRIVAL (Y or N)	FILTER CHANGED (Y or N)	COMMENTS	CHECKED BY